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FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF SECRETARY

Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of	)	
	)	
Revision of the Commission's rules to ensure compatibility with enhanced 911 emergency calling systems	)	CC Docket No. 94-102
	)	

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REPLY COMMENTS OF KSI INC.

Charles J. Hinkle, Jr.

KSI Inc.
7630 Little River Trnpike
Suite 212
Annandale, Virginia 22003
(703) 941-5749

Of Counsel:
Robert B. Kelly
KELLY & POVICH, P.C.
Suite 300
1101 30th Street, N.W.
Washington, D.C. 20007

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SUMMARY

KSI Inc. ("KSI") hereby submits its Reply Comments in this Docket. In response to the NPRM, the FCC received Comments from every interested segment of the communications industry, including companies, like KSI, with location capabilities, public safety organizations, CMRS service providers, and trade associations, among other parties. Although the Commenters differ on a number of issues, there is universal recognition in the Comments that the implementation of wireless E-911 capability in some form would provide many important public benefits and will provide an enhanced emergency response capability to the public safety community.

The Commenters differ, however, on a number of issues concerning the implementation of a wireless E-911 capability throughout the United States. Among these issues are the current state-of-the-art of location technologies and the appropriate scope and timing of implementation of any E-911 requirement adopted in this proceeding.

In its opening Comments, and again in these Reply Comments, KSI demonstrates that its patented "Direction Finding Localization System" or "DFLS" is capable today of meeting or exceeding the NPRM's proposed five year accuracy standard. KSI demonstrates this in Figures 1 through 5 appended hereto depicting actual data gathered from its prototype DFLS system at its Annandale, Virginia headquarters. KSI believes that the misperceptions regarding the state-of-the-art of location technology apparently held by the CMRS interests commenting in

this proceeding firmly evidence the need for FCC leadership in this area to attain the vital public safety benefits offered by wireless E-911 capability.

KSI further encourages the FCC to adopt meaningful E-911 requirements. In this respect, the grandfathering of existing subscriber units as proposed by several Commenters is not only completely unnecessary in view of location techniques that exist today but would render, in KSI's view, essentially meaningless any E-911 requirement.

In particular, over 20 million cellular telephones are in use today, many of which have been purchased for the personal safety uses that have been marketed by the cellular carriers. In five years (or later depending upon the effective date of the E-911 requirement) that number unquestionably will be exponentially higher. Any E-911 requirement that does not apply to existing users, like cellular telephone subscribers, will simply miss coverage of most of the consumers who may benefit from a wireless E-911 capability. The grandfathering of existing subscriber equipment thus will in effect defer for many years (until the change out of that embedded equipment base) the effective deployment of E-911 capability, and must not be viewed as accomplishing any other purpose.

KSI further responds to erroneous statements and misperceptions in the Comments in this Docket.

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REPLY COMMENTS OF KSI INC.

KSI Inc. ("KSI"), pursuant to Section 1.415 of the Commission's Rules, hereby submits its Reply Comments to the Comments submitted on January 9, 1995 in response to the Notice of Proposed Rulemaking, FCC 94-237 (October 19, 1994) ("NPRM") in the above-captioned proceeding. By its NPRM, the FCC has proposed, *inter alia*, rules requiring the provision of enhanced 911 ("E-911") services by Commercial Mobile Radio Service ("CMRS") providers. To this end, the Commission has proposed to phase in over five years a requirement that CMRS systems be capable of providing Automatic Location Information ("ALI") in connection with 911 calls, noting its goal of ensuring that "mobile radio service users on the public switched telephone network have the same level of access to 911 emergency services as wireline callers." NPRM at para. 37.

In response to the NPRM, the FCC received Comments from every interested segment of the communications industry, including companies, like KSI, with location capabilities, public safety organizations, CMRS service providers, and trade associations, among other parties. Although the Commenters differ on a number of issues, there is universal recognition in the Comments that the implementation of wireless E-911 capability in some form would provide many important public benefits and will provide an enhanced emergency response capability to the public safety community.

The Commenters differ, however, on a number of issues concerning the implementation of a wireless E-911 capability throughout the United States. KSI, for example, demonstrated in its Comments that its patented "Direction Finding Localization System" or "DFLS" was capable of providing Automatic Location Information ("ALI") with a level of accuracy sufficient to meet the NPRM's proposed five year accuracy standard (KSI Comments at 8-10), and in fact requested that the FCC tighten the five year accuracy standard. Indeed, the C.J. Driscoll & Associates survey referenced in the NPRM studied the capabilities of DFLS and a number of other location techniques, including terrestrial and satellite alternatives. Other Commenters have noted the capabilities of their location technologies as well.

A number of Commenters in this Docket, principally those representing the interests of CMRS service providers, however, question the availability of adequate and suitable alternatives for implementing wireless E-911. In general, the providers of telecommunication services, and the developers of equipment for providing those services, have expressed the view that technologies for providing ALI are currently immature. These parties, while expert in commercial communications technologies, however, have not typically yet been involved in the development and deployment of localization techniques.

As noted in KSI's Comments (at 1-2), the location industry is evolving principally from the defense sector of the economy where localization technologies have been successfully embodied in defense applications and used to help defend the United States' interests in both war and peace for the last 50 years. Location systems have been and are currently in use to precisely identify and locate both friend and foe in the air, on and under the seas, and on land. KSI, and others, have designed, developed and implemented these systems to work in situations and environments vastly more demanding than that of the wireless community.

KSI welcomes and invites the attention of the CMRS marketplace to developments in location finding techniques in general and to DFLS in particular. Clearly, the interest of the CMRS community in localization has been spurred by the leadership of the FCC and the public safety community evidenced in the NPRM. KSI suggests that the views of the Commenters who suggest that localization technologies are not sufficiently mature to support the adoption of an E-911 requirement are simply misplaced.

As KSI noted in its Comments (at 9), localization is not magic. It is a matter of signal detection, signal processing and data analysis for signal source localization, most of which are not even unique to location determination. Localization employs some combination of hardware and software, sometimes offthe-shelf hardware and software, to dervive the locations. Employing this architecture, KSI's DFLS technology has been operational for several years and has been demonstrated to be effective both in localizing short, control signals and in tracking extended, voice signals from standard, unmodified mobile telephones.

KSI included in the Appendix of its Comments in this Docket several PC system screen displays of <u>actual ALI and ANI data</u> obtained from the current DFLS configuration located at KSI's headquareters in Annandale, Virginia. Additional, field-trial data is included in Figures 1 through 5 appended to these Reply Comments. As these Figures clearly show, KSI's DF processing does indeed routinely provide the needed accuracy for locating both control (data) and voice mobile transmissions from stationary or mobile phones.

Figures 1 and 2 display the results of successively calculated locations of control ("C") and voice ("V") transmissions from standard, .6 watt ("H") and 3 watt ("B") cellular telephones at stationary locations. These results are calculated from the cellular signals received at only two sensor sites separated by nearly a mile, the "SS" in the bottom, right of the Figures and the "CS/SS" in the central, left. These "stationary" results are analyzed for assessment of the repeatability of the measurement process. At each stationary location, white dots are shown for the positions calculated for 25 to 40 distinct signal transmissions. Of course, the results for the "control" channel signals were obtained from a set of individual calls to or from the mobile unit. From the statistics associated with each location, we have calculated and displayed the two-standard-deviation (2-s.d.) ellipse parameters associated with the individual data sets. The semimajor and semiminor axes are shown in units of meters, and the angle-of-arrival (AOA) variability is shown as the 2-s.d. bearing "confidence" to each of the CS and SS. For consideration in localization accuracy specifications, the radius of circular error probability is the geometric mean of the semimajor and semiminor axes, and the 2-standard deviation ellipse has an 86.47% probability of containment.

Figures 1 and 2 show that the accuracy obtained from particular signal receptions will vary. Most obvious in these results is the large ellipse and scatter in the voice localization data collected from the phone that was located approximately on the baseline between the two receiving sites. Of course, when this geometric relation exists between the two sites, the AOAs are directed toward each other and there is no information that distinguishes where along the baseline the transmitter is. With an implementation of the DFLS technology in the distributed sensor sites of a wireless communications system, typically three to five sites will obtain AOA measurements for any individual transmission and the two-site baseline uncertainty will not likely occur. The redundancy in the information from the multiple sites further enhances the accuracy and stability of the localization process.

The results presented in Figures 3 and 4 show the tracking of a mobile phone in motion as it is assigned to a voice channel. This capability will be necessary for providing assistance to a distressed caller who is in motion, and will also be applied at the PSAP in interpreting the information from third-party callers reporting needs for assistance at locations described relative to their own current locations. Thus, the specification of the interfaces with the PSAPs must accommodate the sequential updating of location information as the communications are in progress.

Finally, Figure 5 depicts the integration of actual DFLS-derived location data with mapping software provided by Autometrics. This screen demonstrates a display in a format that will enable the Public Safety Answering Point ("PSAP") to rapidly respond to the emergency caller.

Although KSI believes that the capability to meet the proposed five-year ALI accuracy standard exists today, it also recognizes that further refinement and development of these capabilities to attain improved performance and lower cost will facilitate the expeditious deployment of the E-911 infrastructure. For this reason, and as detailed in its Comments (at Appendix B), KSI is developing its "Enhanced Direction Finding System" or "EDFS," which will require less infrastructure investment than DFLS. KSI is continuing unabated its efforts to further develop both DFLS and EDFS. KSI regards the adoption of a meaningful E-911 requirement as proposed in the NPRM, however, as particularly critical to stimulating the needed research and development by CMRS service providers to ensure that the location technologies may be expeditiously and smoothly integradted into CMRS wireless communications networks.

To this end, over the past several years, KSI has held many discussions regarding location technologies in general and DFLS in particular with both comunications equipment manufacturers and service providers. The equipment manufacturers indicated that they would be interested in the provision of location capability if their customers, the CMRS providers, had interest, but that no providers were requesting localization capabilities. The CMRS providers also advised that they only buy complete turnkey systems, were not privy to proprietary manufacturers' software regarding possible integration techniques, and expressed the concern that location technologies may not work under all conditions.[1] Certainly there was the belief that although, as is apparent in the Comments to the NPRM, the provision of E-911 was a laudable goal for wireless customers, there existed no requirement for deployment and thus no funds for implementation.

In KSI's view, the Comments of CMRS interests in this proceeding confirm its earlier discussions that generally have

[1] Current wireless communications systems did not always work when initially deployed, and even now don't work under all conditions. There are urban "canyon" areas where wireless calls either can't be placed or are dropped. Wireless communications are often difficult in buildings and other "dead spots." However, no one questions the value of the wireless approach either as a communication means or as a valuable 911-enabling capability. Neither the system nor the technology is considered immature or worthless because you can't always make a wireless phone call.

demonstrated only an academic interest in the CMRS community to date in the deployment of location capability within their networks, and not the real momentum that is needed to drive that deployment. KSI recognizes, of course, that many of the concerns of the CMRS community must be addressed to attain robust implementation of E-911 capability. Given the acknowledged public safety benefits resulting from wireless E-911 capability, KSI thus believes that the FCC's leadership in this area will result in the real momentum that has been missing thus far.

<u>Impressions And Misperceptions From The NPRM Comments</u>

Although the Commenters in this Docket generally supported the concept of E-911 in the wireless context, many argued for specific exceptions from a rule of general applicability. For example, several parties suggested that the FCC should "grandfather" all existing CMRS sunscriber equipment existing as of the final effective date of any E-911 requirement. This grandfathering is not only completely unnecessary in view of location techniques that exist today but would, in KSI's view, render essentially meaningless any E-911 requirement.

In particular, over 20 million cellular telephones are in use today, many of which have been purchased for the personal safety uses that have been marketed by the cellular carriers. In five years (or later depending upon the effective date of the E-911 requirement) that number unquestionably will be exponentially higher. Any E-911 requirement that does not apply to existing users, like cellular telephone subscribers, will simply miss coverage of most of the consumers who may benefit from a wireless E-911 capability. The grandfathering of existing subscriber equipment thus will in effect defer for many years (until the change out of that embedded equipment base) the effective deployment of E-911 capability, and must not be viewed as accomplishing any other purpose.

Infrastructure-based location technologies, such as DFLS, in fact will enable E-911 coverage of existing CMRS subscribers without requiring any retrofitting of subscriber equipment. Many new capabilities have been introduced into commercial communications networks over the past decade, including for example call answer, call forwarding and conference calling, without requiring retrofitting of subscriber equipment and without establishing a "second class" customer unable to access the service because of outdated subsciber equipment. E-911 capability, which KSI and many others view as serving a critical public safety function, should be entitled to no less.

Several Commenters advised against the adoption of the NPRM's successive stages on the basis that resources would be expended needlessly on "throw away" facilities. Alternatively, KSI interprets the intent of the Commission's progressive plan to require in stages 1 and 2 the initiation of establishment of the necessary interfaces between the providers' facilities and the call routing and PSAP facilities to culminate in the completion of those interfaces in stage 3. Thus, for example, the initial provision of cell (face) identity would not be abandoned in later stages, even if it became superfluous. As an alternative, the cell (face) identity represents a crude form of the caller's location. Either the cell antenna location (in the case of an omnidirectional cell) or the location of the "center" of a cell sector (in the case of a sectorized cell site) could be provided to the PSAP along with a representation of the large area of uncertainty that should be associated with such a location. With the application of operational experience, the area of uncertainty could even include the effects of the handling of calls at sites that are not "closest to" the caller's location. In any case, this preliminary form of location information can be used in the routing of a call to the appropriate PSAP. Then, in later stages, the location information merely becomes more refined and accurate, and the described areas of uncertainty associated with the calls become smaller. Thus, the routing of the calls becomes increasingly more accurate and efficient, and the PSAP's operators become increasingly more confident of the information and require progressively less time to dispatch a response. Nevertheless, the provision of even the less accurate Phase I information will assist the operator in making more effective queries about the caller's location to more rapidly dispatch the needed services.

In various comments, a reluctance was expressed against any form of implementation of localization capability until the "best" method of localization is determined. KSI believes that it is not necessary to determine the method of localization in order to begin to establish the interfaces between the CMRS provider's facilities and those of the PSTN and PSAP that will exploit the location information. The format of the location information should not change as the technology and accuracy for the information evolve. We should presume that locations may be derived from information provided by network-based equipment (as with the DFLS approach), by the mobile unit (as with GPS-based approaches), and perhaps by external base systems. Standard interfaces in the provider's facilities should be specified to accommodate the reception of location information from the mobile unit, and perhaps from an external system, even when the system is network-based and independently derives location information from the physical properties of the received signals. A robust system will integrate such information from whatever source it is available, and will then apply it and provide it in the interactions with the PSTN and PSAP.

In its characterization of the technical approaches to localization, AT&T correctly described the time difference of arrival ("TDOA") approach as requiring a GPS-based or equivalent time reference at each receiving site. This is needed to achieve the time tagging of the reception of the signal data to an accuracy of not greater than one fourth of a microsecond for 50 meter localization accuracy.

AT&T, however, erroneously described DF approaches as requiring the same equipment as TDOA systems, as well as the phased array antennas that enable the extraction of the AOA information. In fact, the DF approach does not require such onerously accurate data time tagging. KSI's DFLS configuration, from which the results in the appended Figures were obtained, only requires inter-site synchronization to within approximately one second. AT&T's concerns about the effects of multipath signal propagation on location accuraccy in an AOA system have been addressed in KSI's Comments (at n. 3), and are further answered by in the results provided in the enclosed Figures.

In addressing DFLS capabilities, AT&T stated in its Comments that it was not aware that KSI has developed a sectorized DF array for use at sectorized sites or on the sides of buildings. KSI notes that, although a particular site has been sectorized for the handling of communications, it is not necessary that the DF antenna be correspondingly sectorized. In fact, at most such sites, the DF antenna will be preferentially open to full azimuth view so that it can determine the AOAs from any of its surrounding sectors. However, for the sites at which it is appropriate for a DF antenna to be placed on the side of a building, KSI has indeed developed an antenna configuration that will enable the necessary AOA measurements.

In response to those commenters that suggested that DF techniques are not applicable to signals of short duration, we note that such views are not supported in the theory of signal processing and are certainly demonstrated to be incorrect by the data provided in Figure 1. In fact, KSI has already demonstrated with our results that even the short duration signal bursts for the frames involved in TDMA communications support the same localization accuracies presented in the Figures. Benefits in the stability of results available from the temporal integration of signals over extended durations certainly apply to DF signal processing as well as to any other signal processing. All forms of signal processing are affected by the available signal-to-noise ratio and the available quantity of information (i.e., the time-bandwidth product), and the standard, Cramer-Rao, statistical evaluation of any signal analysis process indicates the improvements that are achievable with the integration of additional information.

In its Comments, Elert & Associates state that the accuracy to be expected from an angle of arrival system is only 1000 feet and that its implementation costs are extreme. Certainly, neither signal processing theory nor the results included herein support such a characterization of the accuracy, and the implementation costs that we have described in our previously submitted comments will not be excessive. Though they have described the DF acquisition time as being "in terms of minutes," the results presented herein for the control channels were obtained for signal intervals of less than one tenth of a second. The accuracies achievable with DFLS are more than adequate for the support of 911 responses, and will certainly support other fleet management and monitoring applications. As Elert & Associates indicated, the DF technology does apply phased antenna arrays to obtain the needed AOA measurements, and these facilities are exactly what are already planned in those sites for which "smart antennas" will be installed.

CONCLUSION

For the reasons set forth herein, KSI urges the FCC to expeditiously adopt the NPRM in this proceeding with the modifications suggested in KSI's Comments (at 19-22).

Respectfully submitted,
KSI Inc.

By: Charles J. Hinkle, Jr.

KSI Inc.
7630 Little River Turnpike
Suite 212
Annandale, VA 22003
(703) 941-5749

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FIGURE 1

Scatter Plot of Stationary Locations
(Control Channel)

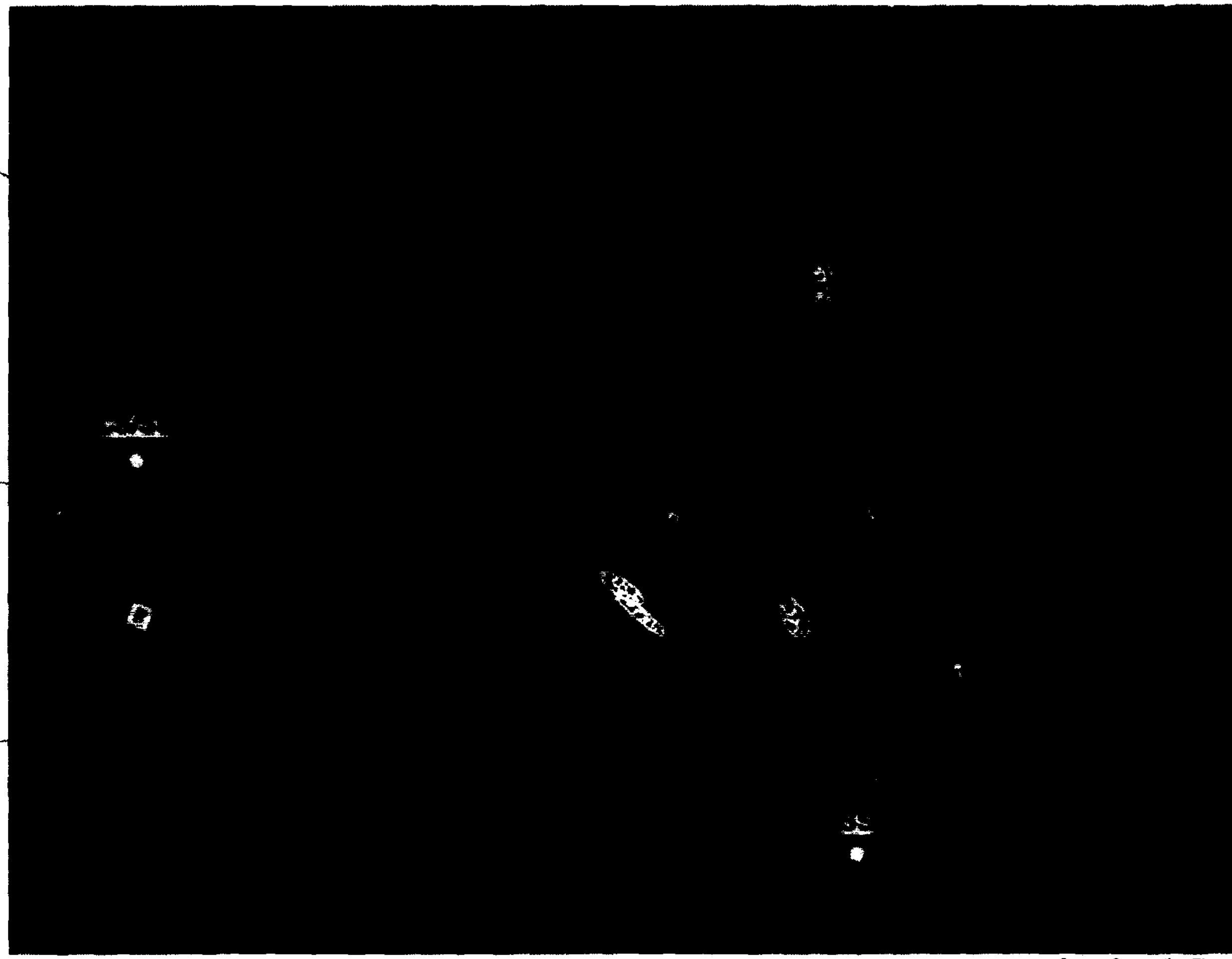
CBP0118
smaj = 12 m
smin = 5 m
Cbconf = 0.7 deg
Sbconf = 0.7 deg

CBQ1228
smaj = 29 m
smin = 16 m
Cbconf = 1.7 deg
Sbconf = 1.2 deg

CHS0119
smaj = 35 m
smin = 10 m
Cbconf = 1.4 deg
Sbconf = 1.6 deg

CHC0127
smaj = 30 m
smin = 15 m
Cbconf = 1.6 deg
Sbconf = 2.9 deg

CBS0118
smaj = 39 m
smin = 7 m
Cbconf = 1.3 deg
Sbconf = 1.3 deg



Air Survey Corporation Photo

FIGURE 2

Scatter Plot of Stationary Locations
(Voice Channel)

Air Survey Corporation Photo

FIGURE 3

Scatter Plot of Vehicle Track Locations
(Voice Ch./0.6 Watt Phone/Clear & Calm)

Air Survey Corporation Photo

VHT0127B

FIGURE 4

Scatter Plot of Vehicle Track Locations
(Voice Ch./3 Watt Phone/Clear & Calm)

Air Survey Corporation Photo